FINANCING

Zero-Emission Buses in Europe

DECEMBER 2020

MUFG Bank Ltd
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Contents

Introduction

The transition to a sustainable net-zero economy is moving quicker than ever before thanks to the focus on the impact of climate change from (i) governments, (ii) regulators, (iii) investors and (iv) the general public. Critical to further progression of this ambition is the development of sustainable transport across road, rail, air and sea modes, by harnessing new fuel sources and supporting changing mobility needs.

Whilst public bus transport services are preferable environmentally to conventional car use, they still contribute a large share of carbon emissions because the bus networks are currently underdeveloped in their transition away from diesel. The roll-out of hybrid vehicles has been popular, but deploying Battery Electric Buses (BEBs) and hydrogen-powered Fuel Cell Electric Buses (FCEBs) will be crucial to creating a zero-emission network.

Several cities have targeted low-carbon networks – for example Copenhagen by 2025, Gothenburg by 2030, London by 2037 and Paris by 2040 – but more is required to replace the EU's 770,000-strong bus fleet into vehicles suitable for a zero-emission future.

This article seeks to (i) highlight the scale of required fleet replacement, (ii) summarise the green bus technologies and (iii) address some of the key challenges of BEB and FCEB deployment as well as the funding considerations which are important to enabling commercial debt financing of green bus fleets.

The Role of Buses in Low-Carbon Transport

There is increasing social pressure and environmental necessity to create a low-carbon economy, including reducing traffic density and deploying greener technologies to improve air quality. Mass lockdowns following the Covid-19 outbreak have highlighted the benefit of reducing transport emissions, with one study estimating a 30-50% reduction in NO_2 emissions across Western Europe[1]. Increasing public transport use will be critical to sustaining this trend. Research in the UK indicates that buses are the fourth biggest carbon-emitting vehicles after domestic flights, long-haul flights and cars with a single passenger[2], therefore greener bus technologies are crucial to enable the transition to a low-carbon economy.

The emphasis of low-carbon transport in recent years has been on the roll-out of battery electric vehicles (BEVs) for personal use, placing the burden of transition on consumers' willingness to switch away from conventional internal combustion engines (ICE). Whilst widespread adoption has so far been hindered by a limited roll-out of related charging infrastructure and the often expensive upfront cost for purchasing BEVs, momentum has begun to pick up with ever stricter emissions standards and indeed the UK and other governments legislating for the complete phasing out of ICE vehicles. Such EV demand stimulants have been complemented by capital pouring into the charging infrastructure landscape from various stakeholders with contrasting interests in the sector's development. More information on this topic will be available in 'Financing EV Charging' – an upcoming edition of this Low Carbon Series.

Public bus transport can arguably expedite a more conducive environment for the deployment of new low-carbon technologies given the scale and potential social impact that investment in large fleets of green buses in towns and cities can have. The expansion of related infrastructure stemming from these fleet investments could also deliver benefits for the speed of adoption of low-carbon personal or business-use vehicles, thereby supporting the wider transport transition. It is foreseeable that where significant investment has been made in new or modified grid connections for green bus charging, potential ancillary revenue streams may be available for local on-street or off-street EV charging targeted at the personal EV market. The depot charging concept has also been applied to large corporate fleets so it is possible that these bus and corporate fleet depots could be co-located at the same grid connection to capitalise on potential economies of scale.

In the past decade the European bus market has seen significant development through the deployment of hybrid ICE buses which make partial use of electrical energy recovery. These buses are a step in the right direction but transition to a zero-emission network will require the deployment of pure green technologies: (i) Battery Electric Buses (BEBs) and (ii) hydrogen-powered Fuel Cell Electric Buses (FCEBs).

Whilst green bus deployment is increasing exponentially, with more BEBs registered in Western Europe and Poland in 2019 than in the 2012-2018 period combined, only 4% of new EU bus registrations in 2019 were BEBs or FCEBs[3]. The recent EU Clean Vehicles Directive will require 25% and 33% of new bus purchases to be 'clean' by 2025 and 2030 respectively, demonstrating the vast gap in deployment to be overcome.

Green Bus Technologies

Both BEBs and FCEBs are technically viable alternatives to the use of ICE in public transport vehicles. It is not a case of which technology is best, but how a combination of deployment of both technologies can solve for the varying requirements of public transport networks at the respective location. However, deployment of BEBs is advancing quicker than FCEBs so far as the BEBs and their charging infrastructure are more readily available at this point – 1,687 BEBs were commissioned across Western Europe and Poland in 2019, compared to 28 FCEBs[4].

[1] Menut, L., Bessagnet, B., Siour, G., Mailler, S., Pennel, R. and Cholakian, A. (2020) Impact of lockdown measures to combat Covid-19 on air quality over Western Europe. *Science of The Total Environment*, Volume 741, p.140426

[2] UK Department for Business, Energy & Industrial Strategy (2020) Greenhouse Gas Reporting: Conversion Factors 2019 *https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019*

[3] ACEA European Automobile Manufacturers Association (2020) Fuel types of new buses *https://www.acea.be/?/press-releases/article/fuel-types-of-new-buses-diesel-85-hybrid-4.8-electric-4-alternative-fuels-6*

[4] SustainableBus (2020) Record year 2019 – the big leap forward of e-bus market in Western Europe *https://www.sustainable-bus.com/news/record-year-2019-the-big-leap-forward-of-e-bus-market-in-western-europe/*

Battery Electric Buses

BEBs use an electric motor for propulsion powered by an on-board battery (typically lithium ion), where the battery is replenished via charging. It is important to distinguish BEBs from trolley-buses which operate via overhead electrical catenary lines and are equally capable of providing a zero-emission bus network but require more intrusive infrastructure to install the lines along bus routes, making them more capital-intensive and potentially less attractive for citizens, city planners (due to the scenery change) and Public Transport Authorities (PTAs).

Urban BEB's are estimated to have a range of 200 kilometres, making them most suitable to shorter distance intra-city journey's which allow more frequent opportunities for charging during operation, depending on the charging infrastructure deployed. Roll-outs are predominantly seen within densely populated cities and towns or for privately-operated shuttle services at airports or leisure parks.

Current estimates place the useful economic life (UEL) of lithium batteries in buses to be around 6-10 years, depending on the charging concept, number of required charge/discharge cycles, depth of discharge, battery performance requirements and temperature environment. This compares to an average bus lifespan of 12 years, which would therefore require buses to have at least one battery replacement during their UEL. Given the current technology available, battery degradation is a key issue in the use of BEBs therefore, whilst technological advancements are in progress, consideration of replacement battery providers is important for any rollout.

At the point of use, BEBs are zero-emission vehicles however it is important to consider that the electricity generation itself can be conventionally or renewably-sourced, therefore end-to-end carbon neutrality is dependent on the source of the electricity that feeds into the charging infrastructure and how the buses are manufactured.

Fuel Cell Electric Buses

FCEBs use an electric motor for propulsion, powered by an inbuilt hydrogen-powered fuel cell which generates electricity by fusing hydrogen with oxygen to directly power the traction motor and auxiliary systems of the bus. The fuel cell provides any excess energy to an on-board battery which is retained for starting the engine, similar to a normal ICE vehicle, and providing supplemental energy when needed – for instance for rapid acceleration or gradients.

FCEBs deliver higher energy output than BEBs, making them better suited for long-distance journeys and routes where stoppage time is limited, for example inter-city, national and international services. Current ranges exceed 450 kilometres and refuelling can be completed in a similar time scale to conventional diesel fuel via Hydrogen Refuelling Stations (HRS).

Current estimates place the UEL of bus fuel cells at around 240,000-400,000km/4-6.5 years, which compares to the average bus UEL of 720,000km/12 years[5]. At least one replacement will therefore be required during buses UEL, which should therefore be captured in any rollout assessment in comparison to existing ICE vehicles.

As with BEBs, the ability for FCEBs to reduce emissions will be determined by the carbon intensity of the hydrogen utilised. As discussed in MUFG's 'Financing the Hydrogen Economy', most hydrogen is currently produced from relatively high carbon sources (classified as "grey" or "brown" hydrogen, extracted from gas or coal respectively). For hydrogen to drive lower emissions, it will increasingly need to be sourced from "green" (electrolysis from low carbon/renewable electricity production) or "blue" (from natural gas with carbon capture and storage) sources.

Related Infrastructure

Infrastructure is a crucial pre-requisite for BEB and FCEB deployment, whether through electrical charging points or HRS, and is a key challenge due to the high amounts of electrical energy required to power BEBs and FCEBs as well as the time constraints to maintain fleet availability and route timetables.

[5] Lozanovski, A., Whitehouse, N., Ko, N. and Whitehouse, S. (2018) Sustainability Assessment of Fuel Cell Buses in Public Transport. *Sustainability*, Volume 10(5), p.1480

BEB Infrastructure

BEBs generally use one of two charging strategies: overnight charging (depot charging) or overnight charging plus daytime short-burst recharging along routes (opportunity charging). The charging strategy and hardware used depends on the technical specifications of batteries, route requirements, installation costs, space to fit within existing infrastructure and transport authority regulations/requirements.

The most common depot charging infrastructure is off-board plug-in, for example as used in London's electric bus roll-outs to date, due to the reduction in space and weight of the on-board battery requirements, as well as the higher charging speed to enable efficient recharging of large BEB fleets. For areas where opportunity charging is used, pantograph-up and pantograph-down are the most common charging methods, for example as used in the Netherlands' Amstelland Meerlanden region, due to their cost competitiveness and easier maintenance compared to wireless induction charging. Whilst other methods such as wireless induction charging, battery swapping and on-board plug-in charging continue to be used in roll-outs, we expect that the majority of BEB deployment will use the most popular methods outlined above.

Any charging strategy requires an integrated grid connection, whether that is solely to the bus terminal for plug-in charging, depot pantographs and battery swapping or more extensively along routes for pantograph and wireless charging. To this end we envisage mutually beneficial partnerships being established that comprise utility companies, bus/battery OEMs and service providers, bus operators, infrastructure investors and PTAs to create effective infrastructure to enable new BEB fleet deployment which contributes to the development of a well-integrated network for battery supply, recharging and management locally, regionally and eventually nationally and internationally.

Six charging technologies are available for BEBs, split into two types – depot and opportunity charging:

Depot Charging

- On-board plug-in – 240V charging provided at bus depots overnight (charging time of 2-6 hours)[6]
- Off-board plug-in – up to 150kW DC charging either after a round-trip or as part of overnight fleet charging (charging time of 0.2-1 hours)[6]
- Battery swapping – physical swapping of battery units at bus depots or specially built stations. Provides immediate electrical energy restoration, but likely to be inefficient for BEBs due to the time taken to swap large batteries

Opportunity Charging

- Pantograph-down – bus stop or depot-mounted pantograph which attaches to fixed conductive rails on bus roofs which can be automatically operated inside buses
- Pantograph-up – rooftop mounted pantograph which connects to a fixed overhead line either along the route or at bus stops
- Wireless – coupled coils/capacitors built into roads to provide wireless charging opportunistically along routes (e.g. at bus stops or identified sections of frequent stopping)

FCEB Infrastructure

Sustainable and economical FCEB deployment will require prior development of HRSs, which is underway to a limited extent across Europe; with 15 publically accessible bus HRSs currently available in Europe and 1 in the UK. HRSs are similar to existing diesel fuel forecourts and would enable quick refuelling of FCEBs (estimated refuelling time of 6 minutes), thereby limiting downtime and maximising availability. In order to facilitate HRS roll-out, sufficient hydrogen infrastructure installation will be required, either via (i) a pipeline network, similar to that envisaged in Germany's 'National Hydrogen Strategy', (ii) storage tanks at HRS refilled via tankers similar to existing diesel forecourts, or more likely (iii) local hydrogen production units using small-scale electrolysers. The latter provides an opportunity to integrate FCEB fleet deployment with hydrogen production to avoid the requirements of an extensive pipeline or tanker distribution network which could hinder FCEB uptake.

As of today, FCEB technology remains expensive which constrains roll-out and the quantity of hydrogen demand, thereby limiting HRS deployment and keeping hydrogen prices high. Support from national and supra-national

[6] Clairand, J., Guerra-Terán, P., Serrano-Guerrero, X., González-Rodriguez, M. and Escrivá-Escrivá, G. (2019) Electric Vehicles for Public Transportation in Power Systems: A Review of Methodologies. Energies, Volume 12(16), P.3114

governments or local cooperation with hydrogen producers (e.g. electrolysers based on wind energy) are critical to further market development and we view the EU's newly-launched Clean Hydrogen Alliance as beneficial to this aim.

Deployment Challenges and Risk Allocation

Bus Market Structure

Across Continental Europe most bus services are operated through concessions, with routes tendered to competing transport operators for periods lasting in the region of 8-15 years. The operators typically own or lease the buses and depots to provide the bus service required under the concession they operate.

The UK bus market is distinctly different in London and outside of London. In London, bus services, procured by Transport for London (TfL), are typically on a 5-7 year concession basis and are regulated. Outside of London, bus routes are generally operated purely on a commercial basis since deregulation in the 1980s, supported by a subsidy framework from national government and local transport authorities to compensate operators for fuel duty charges, provision of free concessionary travel or the operation of non-commercial rural routes. However, this may change in larger cities outside London as a result of the Bus Services Act 2017 which enables local authorities and Public Transport Executives (PTEs) to re-regulate and manage bus services in their area through either partnering with bus operators or tendering on a concession basis.

Deployment Challenges

Under the concession model, the deployment of green buses is determined by the PTAs required proportion of green buses (predominantly BEBs given their more progressed development) as prescribed in the concession tender. These requirements are helpful for ensuring greater green bus deployment however, given the current low operator economics in the bus market, higher total cost of ownership (TCO) for green bus roll-outs could dis-incentivise tender applications unless mitigated through financial incentives within the concession or via external subsidies. In London, for their initial FCEB fleets, TfL owns the buses and leases them to the bus operator presumably in order to overcome the higher TCO of the fleets.

One of the primary challenges is the **high upfront capital expenditure** of green buses compared to ICE buses due to the newer and more sophisticated technology, with estimates placing BEB capex 1.5-2.1x higher than their ICE counterpart. This is counterbalanced to some extent by c.55% lower **cost per kilometre** for BEBs[7] due to the lower price of electricity, however FCEB running costs remain high with hydrogen priced at €13-20/kg in the EU's Clean Hydrogen in European Cities (CHIC) project compared to targeted levels of €4-6/kg to achieve fuel cost parity between hydrogen and diesel[8].

To add to the cost implication for FCEBs, the mitigants for **hydrogen fuel price risk** are underdeveloped given the current uncertainty of long term prices driven by uncertain understanding of both demand and supply. The presence of this unmitigated risk creates difficulty for operators to price such risk in tender bids and therefore is prohibitive of further deployment. Deployment scale supported by intervention by government (and related agencies) will be required to stabilise fuel costs, reduce TCO and make FCEBs economical. For BEBs on the other hand, **electricity markets are developed**, well understood and have financial markets available for power price hedging, which enables operators to accurately model and mitigate price risk for tender bids.

Turning to the **manufacturing** aspect of green buses, in contrast to ICE buses where OEMs are experienced in manufacturing and assembling bus components, BEBs and FCEBs currently require extensive input from a number of parties to combine conventional bus manufacturing with separate battery or fuel cell manufacturing. Additional parties are also involved when considering the consistent and sustainable sourcing of fuel, either through electricity or hydrogen. Contractual arrangements outlining which parties will be responsible in the cases of supply issues, faults or maintenance, whether that be the bus operator, bus OEM, battery OEM and/or 3rd party contractor, are as yet unclear given the limited rollout.

On the **related infrastructure** side of green bus deployment, PTAs will need to give direction on how such infrastructure is provided, whether this is built into bus operators' concession responsibilities or infrastructure is

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[7] Transport & Environment (2018) Electric buses arrive on time
https://www.transportenvironment.org/sites/te/files/Electric%20buses%20arrive%20on%20time.pdf
[8] Fuel Cells and Hydrogen Joint Undertaking (FCHJU), New Bus Fuel (2017) New Bus ReFuelling for European Hydrogen Bus Depots
http://www.newbusfuel.eu/wp-content/uploads/2017/03/NewBusFuel_D4.2_High-level-techno-economic-summary-report_final.pdf

developed independently, and ensure a sufficient timeline is planned to allow for pre-requisite infrastructure to be built before concessions begin. It is currently unclear as to how PTAs will develop such infrastructure effectively, however we do see some joint ventures being formed between utility companies, bus operators and PTAs, for example in the development of BEB depots, and view these as encouraging to facilitating the development of sustainable infrastructure and green bus deployment.

Financing Considerations

Commercial debt financing considerations will vary dependent on whether green buses are (a) owned by the PTA then provided to bus operators, (b) procured by the concession-winning bus operator, or (c) used in bus operations on a purely commercial basis, but important general considerations are:

- **Operational factors** – detailed analysis and understanding of operating hours per day, refuelling/recharging requirements and opportunities, bus availability and maintenance scheduling will be critical to financiers' complete understanding and risk assessment of BEB and FCEB deployment compared to conventional ICE buses, including the core operational risks and mitigants.

- **Regulation and contractual framework** – the regulatory backdrop, contractual frameworks and roles of the public and private sector parties should all have transparency and clarity as they are critical elements to an optimal financing. Amongst other things, this requires a detailed analysis of contractual penalty mechanisms; bus availability criteria and minimum route service quality; how revenues are calculated and distributed; as well as termination provisions and the procuring counterparty's creditworthiness.

- **Redeployment risk** – as there is no established secondary market for green buses and estimating their residual value with confidence is very difficult, if financing for buses and related infrastructure is for longer than a single concession period, redeployment guarantees are likely to be required. This would ensure that subsequent concession operators utilise the bus/infrastructure assets, or the current operator redeploys the buses on other routes which it continues to operate, for their remaining UEL or at least until the repayment of commercial debt. Another alternative is the use of residual value guarantees to cover remaining debt at the end of a concession period. Both mechanisms would significantly mitigate this risk and would also make the financing of green buses more economical from a PTA/public transport user perspective.

- **Battery/Fuel Cell replacement risk** – until the point where technology develops to align battery/fuel cell and bus lifespans, there will be a replacement requirement at least once during a buses UEL. Appropriate contracts will be needed to ensure these are replaced and the replacement cost factored into financing assumptions or guaranteed by a party with adequate financial standing (e.g. parent of operator, battery manufacturer/service provider or PTA).
  Public transport operators might not be willing or may not have the financial capacity to enable a parent company to fully guarantee all green bus financings (especially due to the significant capital expenditures exceeding EUR 5-10bn for larger operators if converting their whole fleet). Therefore, battery performance and replacement risk could be allocated to a party that is best able to manage this risk – i.e. battery manufacturers/service providers that (i) have manufactured the batteries or are active in the secondary market for used batteries, (ii) have a strong credit rating and (iii) are able to provide an availability guarantee to the lessors/operators (e.g. in the form of an extended warranty or battery service agreement). This could unlock substantial amounts of capital in the financing market while providing some relief to operators' balance sheets.
  It is worth noting that, whilst batteries may have a limited UEL for BEB use, they are expected to still have sufficient capacity thereafter for second life applications in other sectors, such as static energy storage. Their sale may partially offset replacement costs for a new battery and some bus manufacturers have already agreed partnerships to enable such repurposing of batteries.

- **Subsidies and Industrial Strategy** – to support the deployment of green buses, a national and/or EU-wide government-supported subsidy framework (that is commensurate to the scale of the required fleet replacement in the UK/Europe) would be beneficial to mitigating the current higher TCO of green buses, thereby improving the financial profile of individual concession contracts and increasing their viability. For example the Ultra-Low Emission Bus Scheme in the UK which runs from 2018-21 contributes 50% of the cost difference between BEB/FCEB and ICE buses along with a 75% contribution to infrastructure installation. National and EU-wide industrial strategies that contribute financially and strategically to the development of supply chains for green buses, so that they have sufficient capacity and are efficient, would also be a strong boost to this sector.

- **Infrastructure** – related infrastructure could be included within a concession or tendered for independently and either method requires appropriate assessment to ensure consistent network availability and electricity/hydrogen supply. For such infrastructure to be financed by commercial debt, lenders will need strong visibility on the cashflows that will repay debt over the asset life. Such visibility is difficult to foresee without support (e.g. guaranteed payment or usage) from either financially strong operators or PTA's.

- **Green Financing** – the financing market has seen the strong growth of environmental and sustainable financings over the last year. As green bus financings are perfectly aligned with this trend, they will substantially benefit from banks' and investors' increasing appetite to prioritise those investments. In addition, European policy makers and regulators are currently discussing the implementation of a "green supporting factor" for banks – e.g. by cutting the capital charges for banks' climate-friendly lending. Whilst not removing the bankability considerations outlined above, which still need to be addressed, this would be another strong driver for deploying larger green bus fleets and achieving environmental targets.

BEB and FCEB bus fleets could be financeable in the commercial debt market provided that the project demonstrates strong contractual payment mechanisms and clear allocation of risks to those parties best able to manage them with appropriate mitigation where necessary.

Policy support at EU, national, regional and PTA level will be crucial for both BEB and FCEB deployment across the UK and Europe, including the availability of funding initiatives at the national and EU level. The EIB, as well as national development banks, continue to be important funding sources for zero-emission transports projects, for example via the EIBs Cleaner Transport Facility.

Our Outlook

In the near term, we expect the rollout of BEBs across Europe to continue accelerating given that the technology is proven and TCO is lower than FCEBs, therefore currently making it easier to develop a financeable project than newer and more expensive FCEB technology. Studies forecast that the BEB segment will grow to be 67% of the global bus fleet by 2040 with the remainder comprising legacy diesel vehicles and FCEBs[9], therefore substantial financing capacity will be required from private investors, government and commercial banks to deploy at speed to transition to a net-zero carbon economy.

Whilst the long term potential for FCEB bus fleets is also clear, the relatively expensive and unproven technology and the remaining hurdles with respect to infrastructure and fuel risk mean that greater government support is expected to be required until the concept is more proven.

With the right business models and contractual structures MUFG believes there is certainly a commercial debt financing market available to green bus fleets in the near and long term and MUFG is actively working towards bringing such structures to the market.

[9] BloombergNEF (2020) Electric Vehicle Outlook 2020 *https://about.bnef.com/electric-vehicle-outlook/*

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